



# Thames River Watershed Summary

## Flat Brook

### WATERSHED DESCRIPTION AND MAPS

The Thames River watershed covers an area of approximately 19,447 acres in the southeastern corner of Connecticut (Figure 1). The watershed is located in the Towns of New London, Groton, Waterford, Ledyard, Montville, Norwich, and Preston, CT.

The Thames River watershed includes one tributary segment impaired for recreation due to elevated bacteria levels. This segment was assessed by Connecticut Department of Energy and Environmental Protection (CT DEEP) and included in the CT 2010 303(d) list of impaired waterbodies. An excerpt of the Integrated Water Quality Report is included in Table 1 to show the status of this tributary (CTDEEP, 2010).

The Thames River begins at the confluence with the Quinebaug River and the Yantic River at the intersection of Route 12 and Route 2 in the City of Norwich, CT, flows south following Route 12, follows the Montville-Preston border after Trading Cove, follows the Montville-Ledyard border after Poquetanuck Cove, follows the Waterford-Ledyard border downstream of Horton Cove, follows the Groton-Waterford border downstream of Smith Cove, then follows the Groton-New London border downstream of Mamacoke Cove, and outlets at New London Harbor before reaching Long Island Sound. The bacteria impaired segment, Flat Brook (CT3000-08\_01), consists of 1.09 miles of tributary to the Thames River in Ledyard and Groton, CT (Figure 2). This impaired segment begins at an unnamed pond at the base of Baldwin Hill in Groton, CT, flows north downstream to cross Route 12, follows Long Cove Road, and outlets to Long Cove north of the United States Naval Reserve Base at the confluence with the Thames River in Ledyard, CT.

Flat Brook has a water quality classification of A. Designated uses include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. As there are no designated beaches in this segment of Flat Brook, the specific recreation impairment is for non-designated swimming and other water contact related activities.

### Impaired Segment Facts

**Impaired Segment:** Flat Brook  
(CT3000-08\_01)

**Municipalities:** Ledyard, Groton

**Impaired Segment Length  
(miles):** 1.09

**Water Quality Classification:**  
Class A

**Designated Use Impairment:**  
Recreation

**Sub-regional Basin Name and  
Code:** Thames River, 3000

**Regional Basin:** Thames Main  
Stem

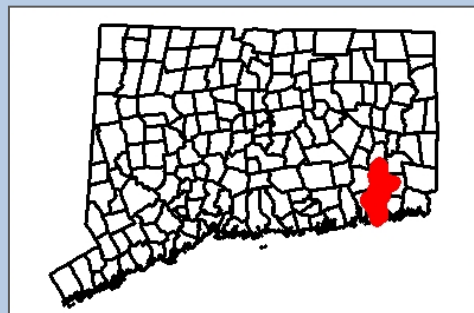
**Major Basin:** Thames

**Watershed Area (acres):** 19,447

**MS4 Applicable?** Yes

**Applicable Season:** Recreation  
Season (May 1 to September 30)

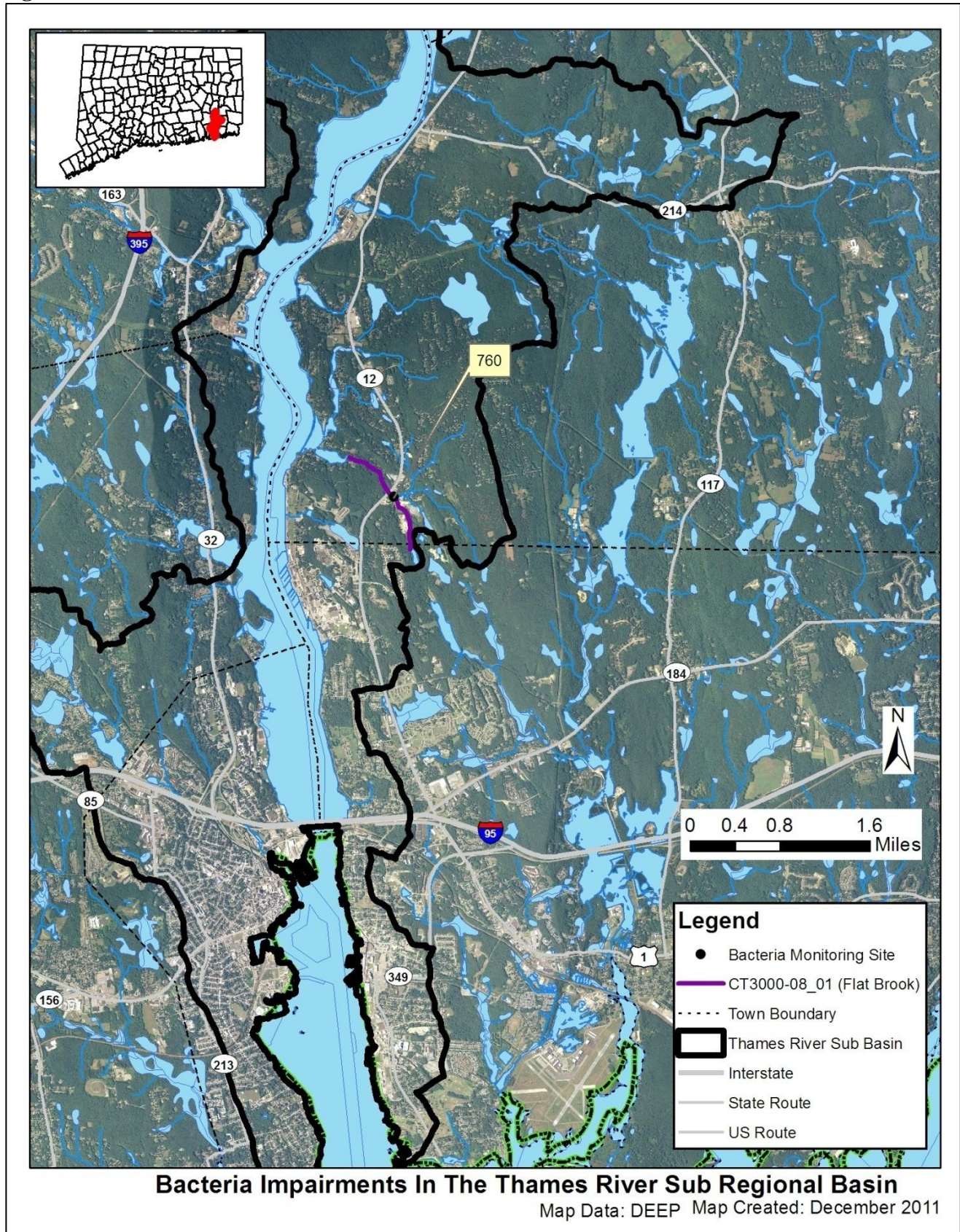
**Figure 1: Watershed location in  
Connecticut**



**Table 1: Impaired segment and nearby waterbodies from the Connecticut 2010 Integrated Water Quality Report**

<b>Waterbody ID</b>	<b>Waterbody Name</b>	<b>Location</b>	<b>Miles</b>	<b>Aquatic Life</b>	<b>Recreation</b>	<b>Fish Consumption</b>
CT3000-08_01	Flat Brook (Ledyard)-01	From mouth at confluence with Thames River (inlet to Long Cove, North of Navy Base) Gales Ferry/Ledyard, US to headwaters at unnamed pond, Groton (Brook runs North).	1.09	U	NOT	FULL
<b>FULL = Designated Use Fully Supported</b> <b>NOT = Designated Use Not Supported</b> <b>U = Unassessed</b>						

**Figure 2: GIS map featuring general information of the Thames River watershed at the sub-regional level**



### Land Use

Existing land use can affect the water quality of waterbodies within a watershed (USEPA, 2011c). Natural processes, such as soil infiltration of stormwater and plant uptake of water and nutrients, can occur in undeveloped portions of the watershed. As impervious surfaces (such as rooftops, roads, and sidewalks) increase within the watershed landscape from commercial, residential, and industrial development, the amount of stormwater runoff to waterbodies also increases. These waterbodies are negatively affected as increased pollutants from nutrients and bacteria from failing and insufficient septic systems, oil and grease from automobiles, and sediment from construction activities become entrained in this runoff. Agricultural land use activities, such as fertilizer application and manure from livestock, can also increase pollutants in nearby waterbodies (USEPA, 2011c).

As shown in Figures 3 and 4, the Thames River watershed consists of 44% urban, 35% forest, 19% water, and 2% agriculture land uses. The Thames River watershed is mostly developed around the Thames River main stem, particularly at the headwaters in Norwich, CT and the lower portion south of Smith Cove in Waterford, CT. Agricultural areas, including hayfields and row crops, are scattered throughout the watershed. The middle portion of the Thames River watershed is characterized by tracts of forested open space areas, including Crandall Property and Crouch Pond, Stoddard Hill State Park Scenic Reserve, PTA Lane Open Space, FW Brown Tract, Connecticut Arboreum, and Ledyard's Glacial Park-Kettle Hole. There are also several developed open spaces, including Norwich Country Club golf course and Milton Green Memorial Field. Dense commercial and industrial development adjacent to the Thames River can be found south of the Route 95 overpass. The impaired tributary to the Thames River, Flat Brook, begins in an open residential development adjacent to a dense suburban neighborhood along Michigan Drive in Groton, CT, and continues north downstream into commercial development, including a large sand and gravel pit with exposed soil, Aqua Sports Diving Center, Terra Firma Self Storage, Student Transportation of America along Baldwin Hill Road, CubeSmart Self Storage, and Baroco Corporation along Route 12 in Ledyard, CT. Flat Brook continues through forested residential development before its outlet to Long Cove.

**Figure 3: Land use within the Thames River watershed**

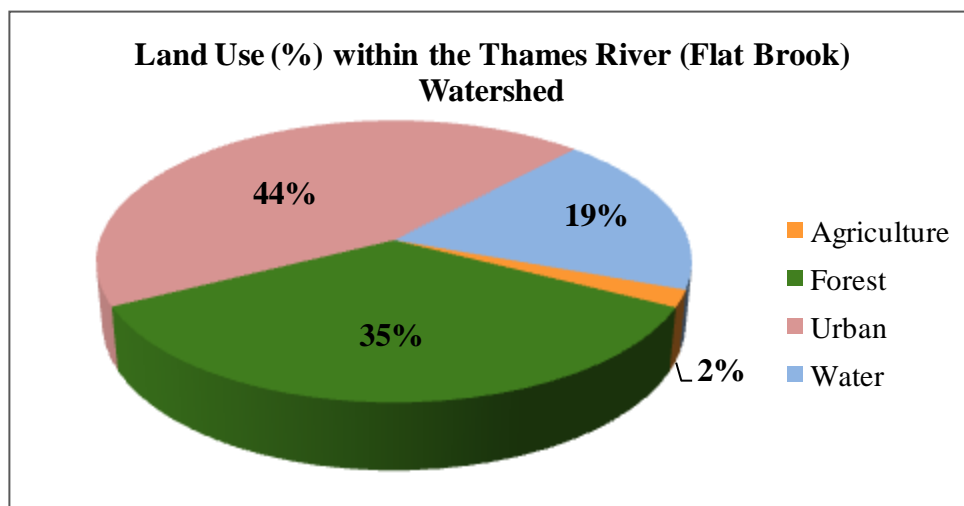
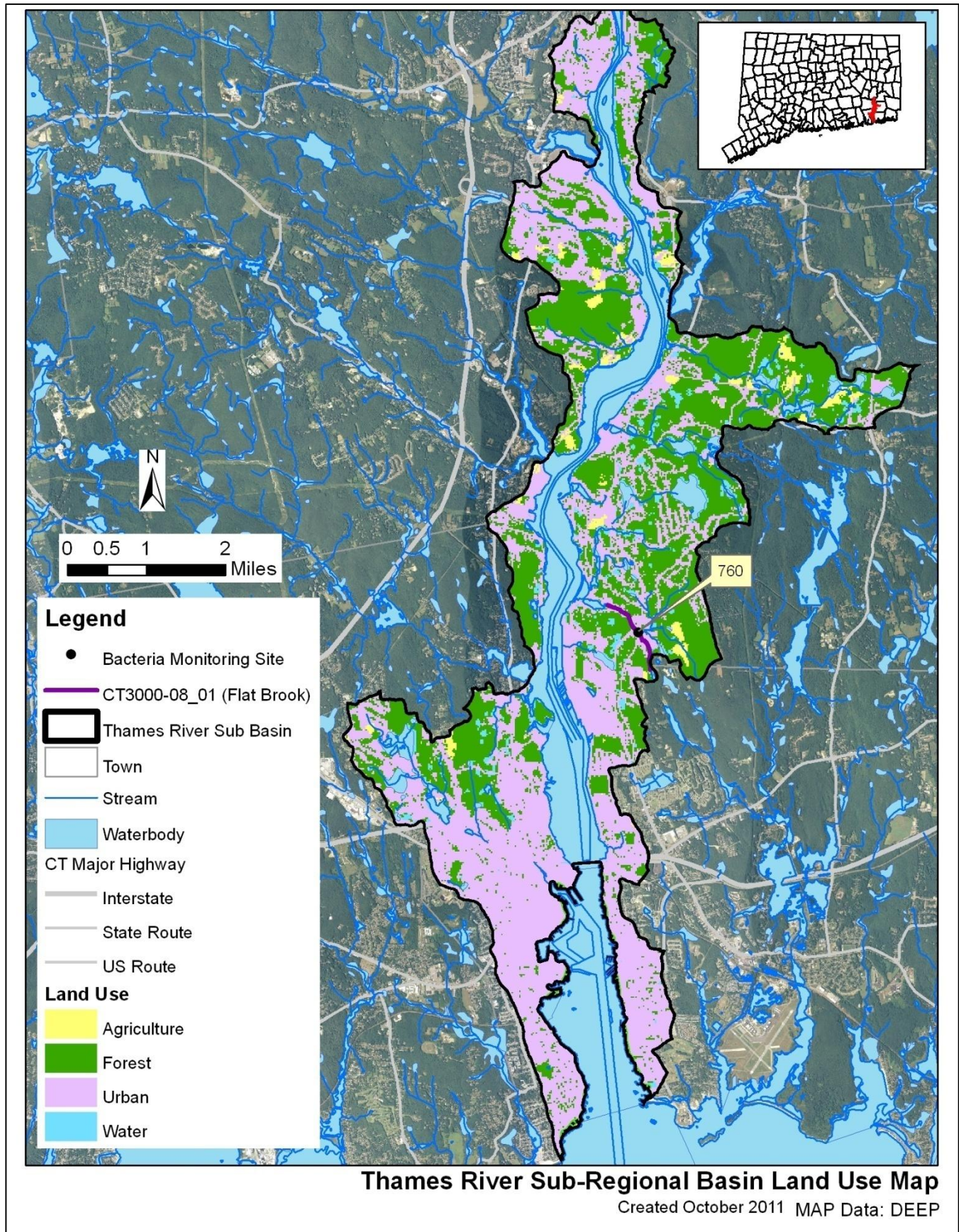


Figure 4: GIS map featuring land use for the Thames River watershed at the sub-regional level



**WHY IS A TMDL NEEDED?**

*E. coli* is the indicator bacteria used for comparison with the CT State criteria in the CT Water Quality Standards (WQS) (CTDEEP, 2011). All data results are from CT DEEP, USGS, Bureau of Aquaculture, or volunteer monitoring efforts at stations located on the impaired segments.

**Table 2: Sampling station location description for the impaired segment in the Thames River watershed**

Waterbody ID	Waterbody Name	Station	Station Description	Municipality	Latitude	Longitude
CT3000-08_01	Flat Brook	760	Baldwin Hill Road	Ledyard	41.406172	-72.074675

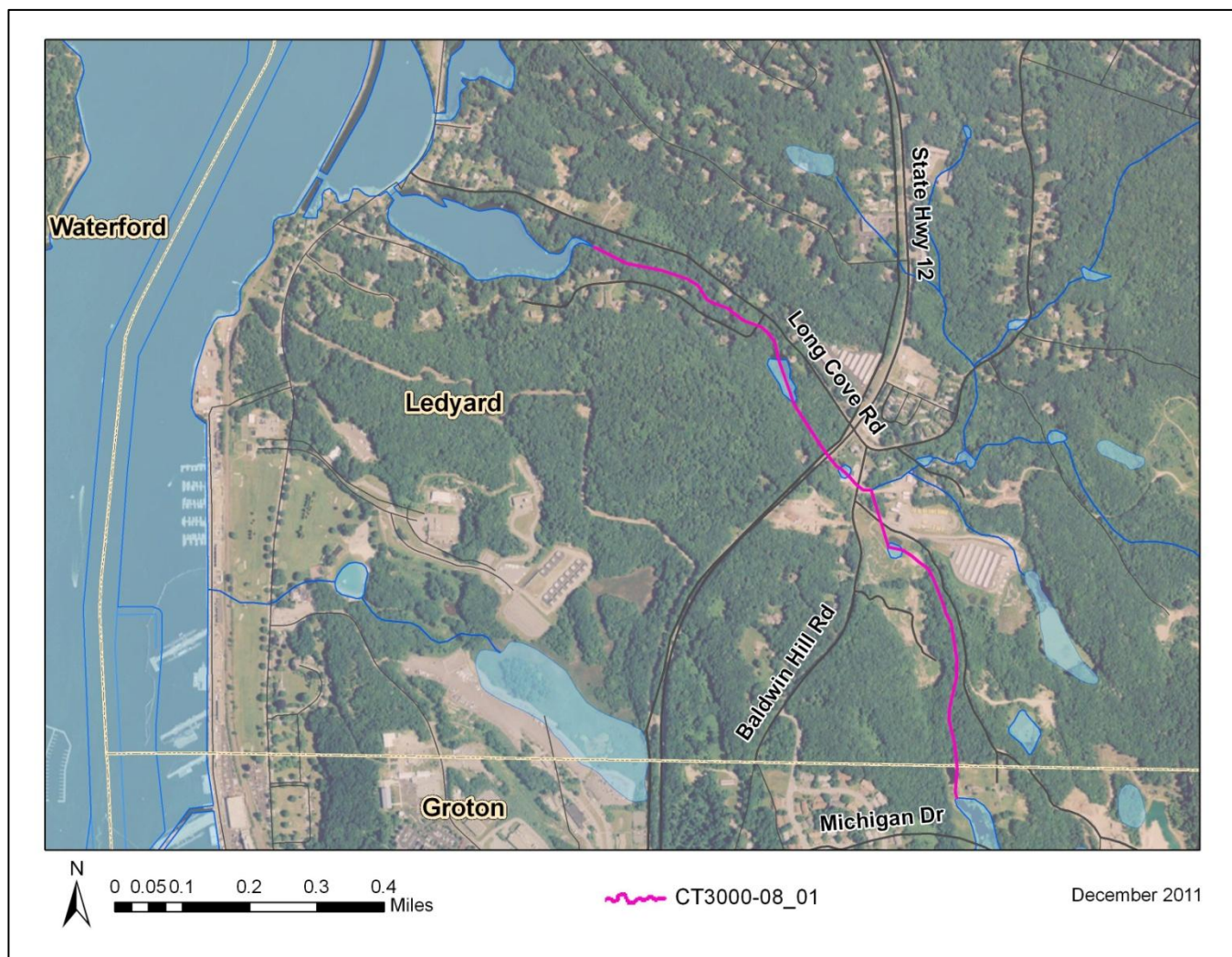
Flat Brook (CT3000-08\_01) is a Class A freshwater river (Figure 5). Its applicable designated uses are potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply. Water quality analyses were conducted using data from one sampling location from 2006-2009 (Station 760) (Table 2).

The water quality criteria for *E. coli*, along with bacteria sampling results for Station 760 from 2006-2009, are presented in Table 9. The annual geometric mean was calculated for Station 760 and exceeded the WQS for *E. coli* for all years. Single sample values at this station also exceeded the WQS for *E. coli* multiple times from 2006-2008.

To aid in identifying possible bacteria sources, the geometric mean was also calculated for each station for wet-weather and dry-weather sampling days, where appropriate (Table 9). For Flat Brook, geometric mean values at Station 760 exceeded the WQS for *E. coli* during both wet and dry-weather conditions.

Due to the elevated bacteria measurements presented in Table 9, Flat Brook did not meet CT's bacteria WQS, was identified as impaired, and was placed on the CT List of Waterbodies Not Meeting Water Quality Standards, also known as the CT 303(d) Impaired Waters List. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with State WQS.

Figure 5: Aerial map of Flat Brook



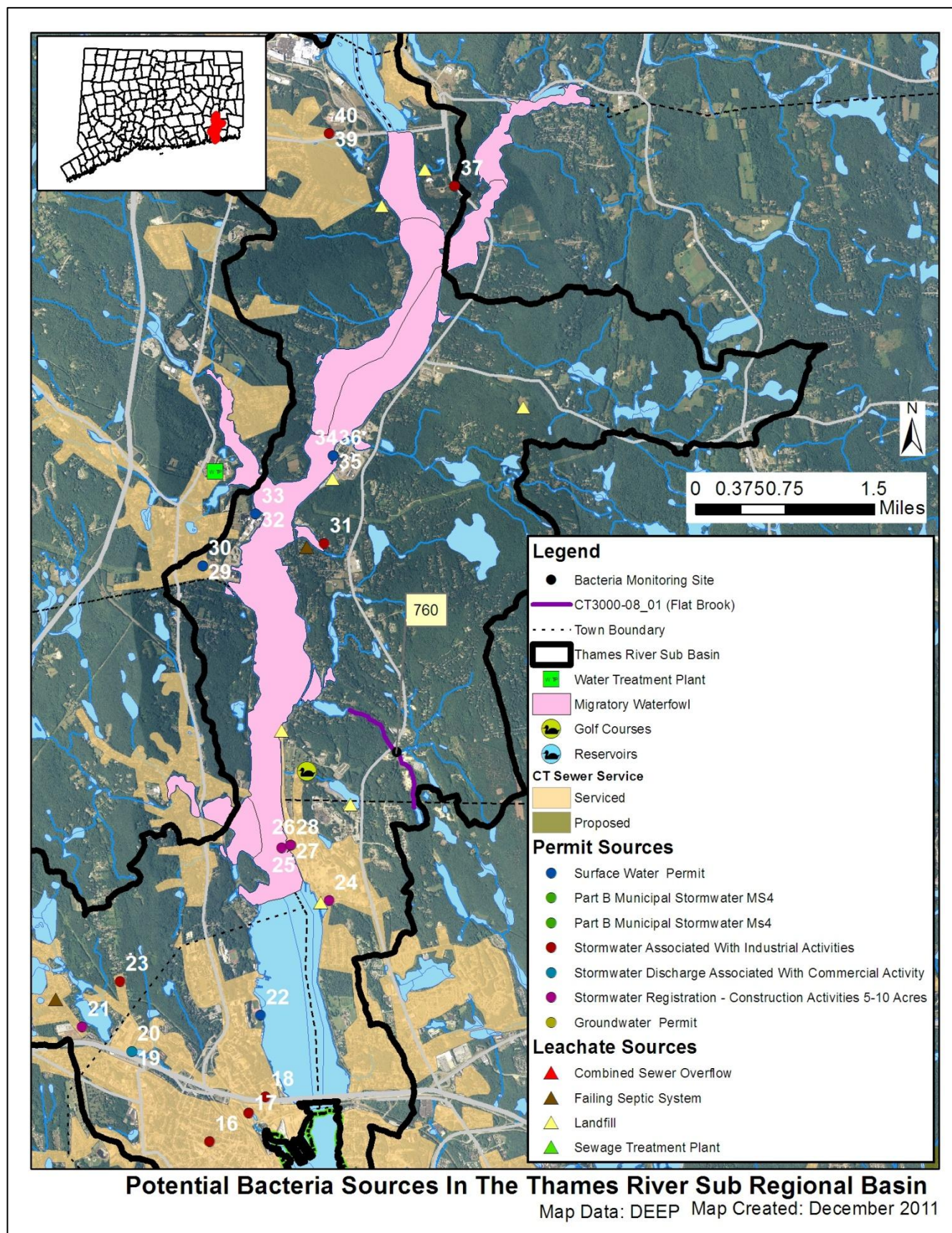
**POTENTIAL BACTERIA SOURCES**

Potential sources of indicator bacteria in a watershed include point and non-point sources, such as stormwater runoff, agriculture, sanitary sewer overflows (collection system failures), illicit discharges, and inappropriate discharges to the waterbody. Potential sources that have been tentatively identified in the watershed based on land use (Figures 3 and 4) and a collection of local information for the impaired waterbody is presented in Table 3 and Figure 6. However, the list of potential sources is general in nature and should not be considered comprehensive. There may be other sources not listed here that contribute to the observed water quality impairment in the study segments. Further monitoring and investigation will confirm listed sources and discover additional ones. Some segments in this watershed are currently listed as unassessed by CT DEEP procedures. This does not suggest that there are no potential issues on this segment, but indicates a lack of current data to evaluate the segment as part of the assessment process. For some segments, there are data from permitted sources, and CT DEEP recommends that any elevated concentrations found from those permitted sources be addressed through voluntary reduction measures. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement these TMDLs.

**Table 3: Potential bacteria sources in the Thames River watershed**

<b>Impaired Segment</b>	<b>Permit Source</b>	<b>Illicit Discharge</b>	<b>CSO/SSO Issue</b>	<b>Failing Septic System</b>	<b>Agricultural Activity</b>	<b>Stormwater Runoff</b>	<b>Nuisance Wildlife/ Pets</b>	<b>Other</b>
Flat Brook CT3000-08_01	<b>x</b>	<b>x</b>		<b>x</b>		<b>x</b>	<b>x</b>	

Figure 6: Potential sources in the Thames River watershed at the sub-regional level



The potential sources map for the impaired basin was developed after thorough analysis of available data sets. If information is not displayed in the map, then no sources were discovered during the analysis. The following is the list of potential sources that were evaluated: problems with migratory waterfowl, golf course locations, reservoirs, proposed and existing sewer service, cattle farms, poultry farms, permitted sources of bacteria loading (surface water discharge, MS4 permit, industrial stormwater, commercial stormwater, groundwater permits, and construction related stormwater), and leachate and discharge sources (agricultural waste, CSOs, failing septic systems, landfills, large septic tank leach fields, septage lagoons, sewage treatment plants, and water treatment or filter backwash).

### **Point Sources**

Permitted sources within the watershed that could potentially contribute to the bacteria loading are identified in Table 4. This table includes permit types that may or may not be present in the impaired watershed. Additional investigation and monitoring may reveal the presence of additional discharges in the watershed. Available effluent data from each of these permitted categories found within the watershed are compared to the CT State WQS for the appropriate receiving waterbody use and type.

**Table 4: General categories list of other permitted discharges**

Permit Code	Permit Description Type	Number in watershed
CT	Surface Water Discharges	0
GPL	Discharge of Swimming Pool Wastewater	0
GSC	Stormwater Discharge Associated with Commercial Activity	0
GSI	Stormwater Associated with Industrial Activity	0
GSM	Part B Municipal Stormwater MS4	0
GSN	Stormwater Registration – Construction	0
LF	Groundwater Permit (Landfill)	0
UI	Underground Injection	0

### ***Permitted Sources***

As shown in Table 7, there are no permitted discharges to Flat Brook. Since the MS4 permits are not targeted to a specific location, but the geographic area of the regulated municipality, there is no one accurate location on the map to display the location of these permits. One dot will be displayed at the geographic center of the municipality as a reference point. Sometimes this location falls outside of the targeted watershed and therefore the MS4 permit will not be displayed in the Potential Sources Map. Using the municipal border as a guideline will show which areas of an affected watershed are covered by an MS4 permit.

### ***Municipal Stormwater Permitted Sources***

Per the EPA Phase II Stormwater rule all municipal storm sewer systems (MS4s) operators located within US Census Bureau Urbanized Areas (UAs) must be covered under MS4 permits regulated by the appropriate State agency. There is an EPA waiver process that municipalities can apply for to not

participate in the MS4 program. In Connecticut, EPA has granted such waivers to 19 municipalities. All participating municipalities within UAs in Connecticut are currently regulated under MS4 permits by CT DEEP staff in the MS4 program.

The US Census Bureau defines a UA as a densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that exceeds the 50,000 people threshold and has a population density of at least 1,000 people per square mile. The UA will also include adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place. (67 FR 11663)

For the 2000 Census a new geographic entity was created to supplement the UA blocks of land. This created a block known as an Urban Cluster (UC) and is slightly different than the UA. The definition of a UC is a densely settled area that has a census population of 2,500 to 49,999. A UC generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UC consists of all or part of one or more incorporated places and/or census designated places; such a place(s) together with adjacent territory; or territory outside of any place. The major difference is the total population cap of 49,999 people for a UC compared to >50,000 people for a UA. (67 FR 11663)

While it is possible that CT DEEP will be expanding the reach of the MS4 program to include UC municipalities in the near future they are not currently under the permit. However, the GIS layers used to create the MS4 maps in this Statewide TMDL did include both UA and UC blocks. This factor creates some municipalities that appear to be within an MS4 program that are not currently regulated through an MS4 permit. This oversight can explain a municipality that is at least partially shaded grey in the maps and there are no active MS4 reporting materials or information included in the appropriate appendix. While these areas are not technically in the MS4 permit program, they are still considered urban by the cluster definition above and are likely to contribute similar stormwater discharges to affected waterbodies covered in this TMDL.

As previously noted, EPA can grant a waiver to a municipality to preclude their inclusion in the MS4 permit program. One reason a waiver could be granted is a municipality with a total population less than 1000 people, even if the municipality was located in a UA. There are 19 municipalities in Connecticut that have received waivers, this list is: Andover, Bozrah, Canterbury, Coventry, East Hampton, Franklin, Haddam, Killingworth, Litchfield, Lyme, New Hartford, Plainfield, Preston, Salem, Sherman, Sprague, Stafford, Washington, and Woodstock. There will be no MS4 reporting documents from these towns even if they are displayed in an MS4 area in the maps of this document.

The list of US Census UCs is defined by geographic regions and is named for those regions, not necessarily by following municipal borders. In Connecticut the list of UCs includes blocks in the following Census Bureau regions: Colchester, Danielson, Lake Pocotopaug, Plainfield, Stafford, Storrs, Torrington, Willimantic, Winsted, and the border area with Westerly, RI (67 FR 11663). Any MS4 maps showing these municipalities may show grey areas that are not currently regulated by the CT DEEP MS4 permit program.

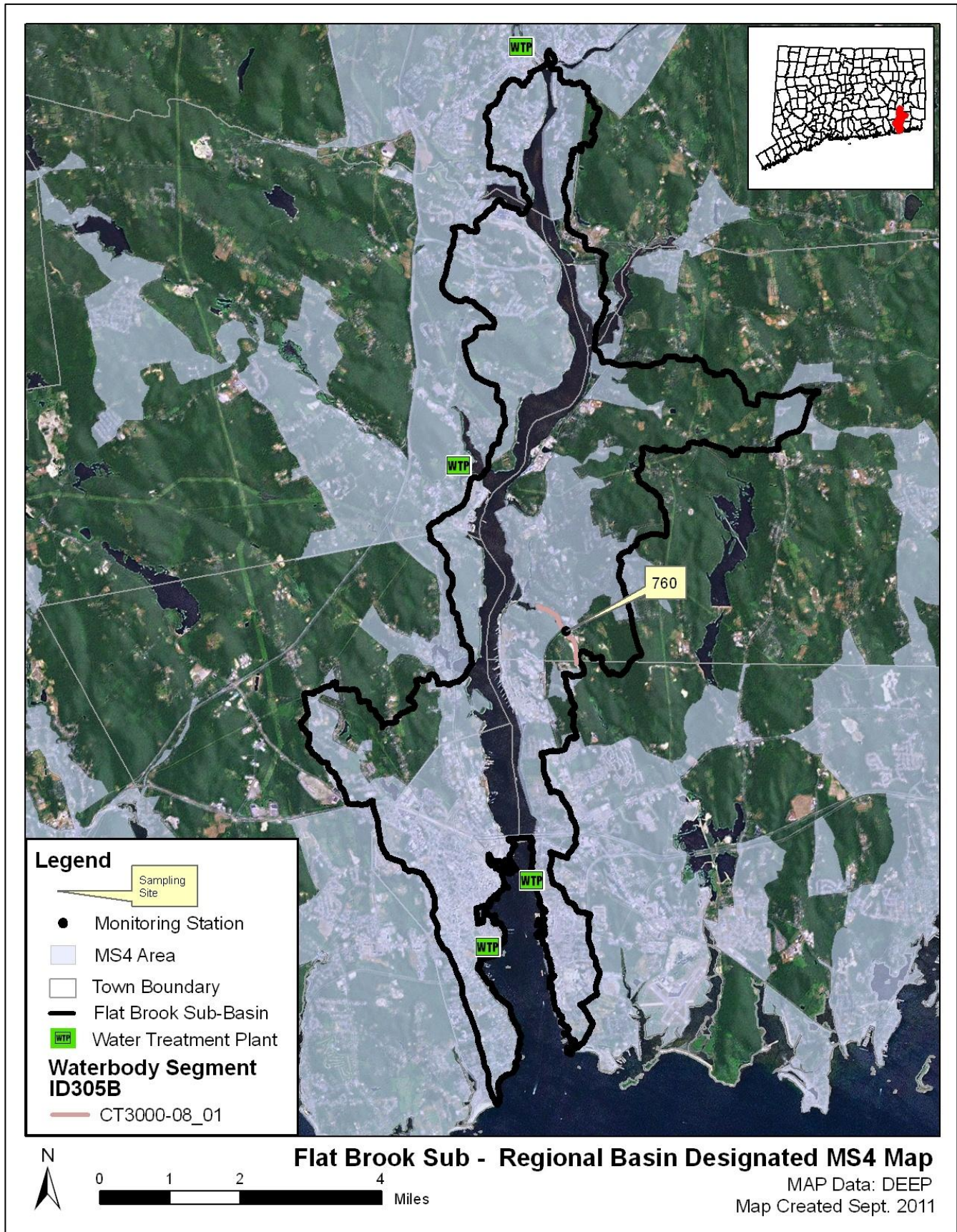
The impaired segment of the Thames River watershed is located within the Towns of Ledyard and Groton, CT. The towns are largely urbanized, as defined by the U.S. Census Bureau, and are required to comply with the General Permit for the Discharge of Stormwater from Small Municipal Storm Sewer Systems (MS4 permit) issued by the Connecticut Department of Energy and Environmental Protection

(DEEP) (Figure 7). This general permit is only applicable to municipalities that are identified in Appendix A of the MS4 permit that contain designated urban areas and discharge stormwater via a separate storm sewer system to surface waters of the State. The permit requires municipalities to develop a Stormwater Management Plan (SMP) to reduce the discharge of pollutants and protect water quality. The MS4 permit is discussed further in the “TMDL Implementation Guidance” section of the core TMDL document. Additional information regarding stormwater management and the MS4 permit can be obtained on CTDEEP’s website:

([http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav\\_GID=1654](http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav_GID=1654)).

Multiple MS4 outfalls have been sampled for *E. coli* bacteria in the watershed (Table 5). In Groton, six MS4 outfalls were sampled from 2005-2008. Of these outfalls, four exceeded the single sample water quality standard of 410 colonies/100 mL. In Ledyard, four MS4 outfalls were sampled in 2006, 2008, and 2009. All outfalls in Ledyard exceeded the single sample water quality standard of 410 colonies/100 mL. In Waterford, two MS4 outfalls were sampled in 2004, 2005, 2007, and 2009. Of these outfalls, none exceeded the single sample water quality standard of 410 colonies/100 mL.

Figure 7: MS4 areas of the Thames River watershed



**Table 5: List of MS4 sample locations and *E. coli* (colonies/100 mL) results in the Thames River watershed**

Town	Location	MS4 Type	Receiving Waters	Sample Date	Result
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	11/10/05	510
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	12/01/06	920
Groton	#12 Thames Street & Pleasant Street	Residential	Thames River	01/11/08	50
Groton	#18 Shore Avenue & Prospect Street	Residential	Thames River	11/10/05	30
Groton	#19 Shore Avenue & Tylon Avenue	Residential	Thames River	11/10/05	20
Groton	#26 Shennecossette Road & Plant Street	Residential	Thames River	11/10/05	10
Groton	#26 Shennecossette Road & Plant Street	Residential	Thames River	12/01/06	550
Groton	#8 Grove Avenue & Bliven Street	Residential	Thames River	11/10/05	10
Groton	#8 Grove Avenue & Bliven Street	Residential	Thames River	12/01/06	580
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	07/08/05	3,800
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	11/30/05	200
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	12/01/06	1,360
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	11/06/07	1,250
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	06/04/08	3,200
Groton	Military Highway & Lestertown Road (outfall 3630R)	Residential	Thames River	06/04/08	4,400
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	07/12/06	900
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	12/01/06	220
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	01/11/08	20
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	04/28/08	40
Ledyard	CIP-1 Baldwin Hill Road	Industrial/Commercial	Thames River	06/09/09	4,610
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	07/12/06	500
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	12/01/06	100
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	01/11/08	100
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	04/28/08	600
Ledyard	CIP-2 Flat Brook Drive	Industrial/Commercial	Thames River	06/09/09	24,200
Ledyard	R-1 Whalehead Road	Residential	Thames River	07/12/06	>2000

**Table 5: List of MS4 sample locations and *E. coli* (colonies/100 mL) results in the Thames River watershed (continued)**

Town	Location	MS4 Type	Receiving Waters	Sample Date	Result
Ledyard	R-1 Whalehead Road	Residential	Thames River	12/01/06	250
Ledyard	R-1 Whalehead Road	Residential	Thames River	01/11/08	30
Ledyard	R-1 Whalehead Road	Residential	Thames River	04/28/08	20
Ledyard	R-1 Whalehead Road	Residential	Thames River	06/09/09	2,360
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	07/12/06	700
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	12/01/06	200
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	01/11/08	20
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	04/28/08	10
Ledyard	R-4 Eagle Ridge Drive detention basin inlet	Residential	Thames River	06/09/09	3,870
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	10/25/05	10
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	05/02/07	10
Waterford	Bolles Court Residential	Residential	Smith Cove, Thames River	01/07/09	10
Waterford	Hickory Lane #10127	Residential	Thames River	09/08/04	178
Shaded cells indicate an exceedance of single-sample based water quality criteria (410 colonies/100 mL)					

### ***Publicly Owned Treatment Works***

As shown in Figure 7, there are two publicly owned treatment works (POTWs), or wastewater treatment plants, in the Thames River watershed in Groton and New London downstream of the impaired tributary. There are no POTWs near Flat Brook, and therefore, POTWs are not a potential source of loading to Flat Brook.

### **Non-point Sources**

Non-point source pollution (NPS) comes from many diffuse sources and is more difficult to identify and control. NPS pollution is often associated with land-use practices. Examples of NPS that can contribute bacteria to surface waters include insufficient septic systems, pet and wildlife waste, agriculture, and contact recreation (swimming or wading). Potential sources of NPS within the Thames River watershed are described below.

### ***Stormwater Runoff from Developed Areas***

The majority of the Thames River watershed is developed. Approximately 44% of the land use in the watershed is considered urban (Figures 4 and 9). Urban areas are often characterized by impervious

cover, or surface areas such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. Studies have shown a link between increasing impervious cover and degrading water quality conditions in a watershed (CWP, 2003). In one study, researchers correlated the amount of fecal coliform to the percent of impervious cover in a watershed (Mallin *et al.*, 2000).

As shown in Figure 8, approximately 36% of the Thames River watershed contains more than 16% impervious cover (Figure 9). Flat Brook is located in the area characterized by 7-11% impervious cover, but flows through commercial development along Route 12, particularly a large sand and gravel pit, Aqua Sports Diving Center, Terra Firma Self Storage, Student Transportation of America, CubeSmart Self Storage, and Baroco Corporation. Water quality data taken at Station 760, located within the urbanized portion of Flat Brook, exceeded the geometric mean during wet-weather, which suggests that stormwater runoff may be a source of bacteria to Flat Brook (Table 11).

**Figure 8: Range of impervious cover (%) in the Thames River watershed**

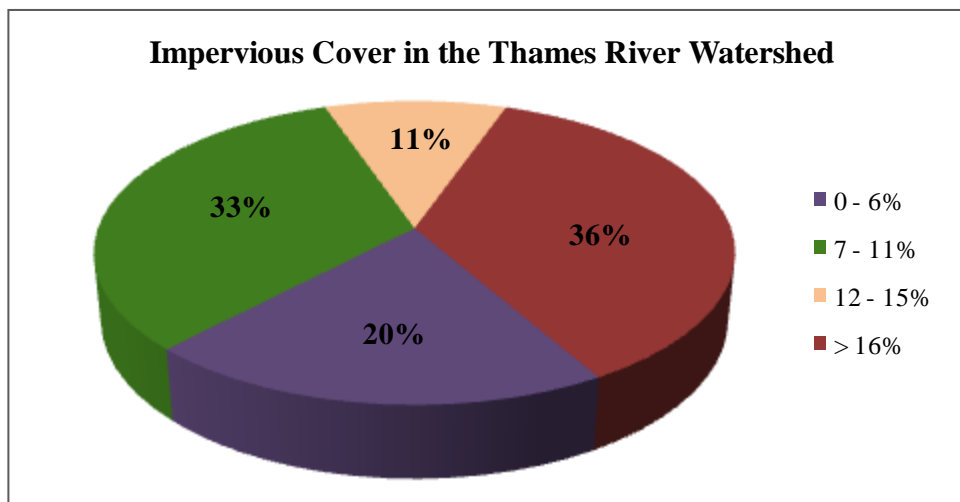
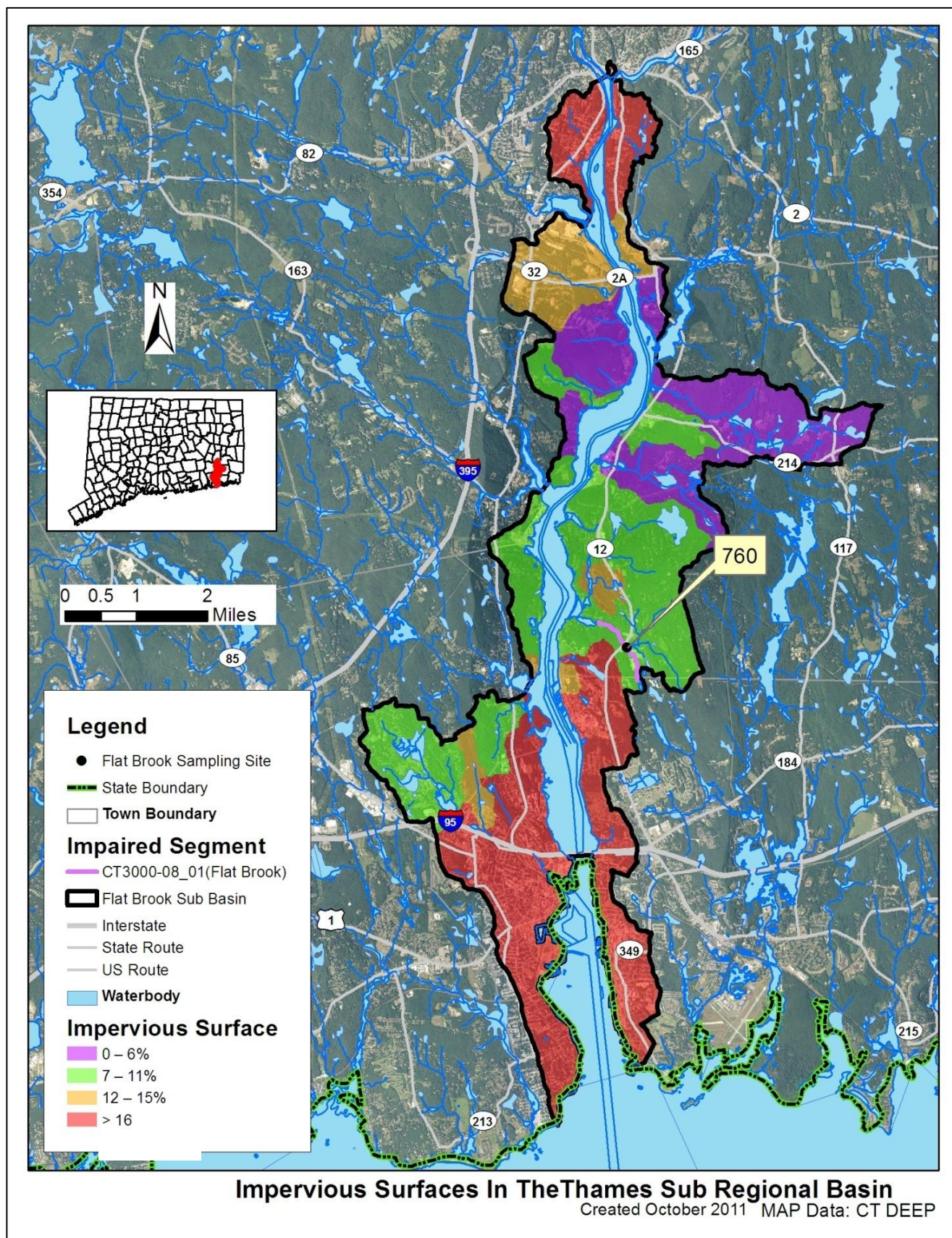


Figure 9: Impervious cover (%) for the Thames River watershed at the sub-regional level



***Insufficient Septic Systems and Illicit Discharges***

As shown in Figure 6, the portion of the watershed within the drainage area of Flat Brook relies on onsite wastewater treatment systems, such as septic systems. Insufficient or failing septic systems can be significant sources of bacteria by allowing raw waste to reach surface waters. A failing septic system north of Flat Brook near Clark Cove and downstream of Flat Brook was identified in Figure 6. Water quality data taken at Station 760 exceeded the geometric mean during dry-weather, which suggests that failing septic systems may be a source of bacteria to Flat Brook (Table 11). In Connecticut, local health directors or health districts are responsible for keeping track of any reported insufficient or failing septic systems in a specific municipality. The Towns of Ledyard (a sovereign nation) and Groton are part of the Ledge Light Health District (<http://www.ledgelighthd.org/>).

The Flat Brook drainage area is an MS4 area, and is likely to have piped storm drainage. It is possible that improper connection between wastewater systems and the stormwater drainage network exist, either through error, illicit connections, or leaks. Therefore, illicit discharges are a potential source of bacteria. The drainage area surrounding Flat Brook is not serviced by the municipal sewer system (Figure 6). As such, sewer system leaks are not a potential source of bacteria.

***Wildlife and Domestic Animal Waste***

Wildlife and domestic animals within the Thames River watershed represent another potential source of bacteria. Wildlife, including waterfowl, may be a significant bacteria source to surface waters. With the construction of roads and drainage systems, these wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface water. These physical land alterations can exacerbate the impact of natural sources on water quality (USEPA, 2001). As Flat Brook flows through forested residential areas near identified migratory waterfowl habitat along the Thames River, waste from wildlife and domestic animals, such as dogs, may be contributing to bacteria concentrations in Flat Brook.

As shown in Figure 6, the Goose Run golf course is located along the Thames River south of Flat Brook and out of Flat Brook drainage area. However, Flat Brook flows into identified migratory waterfowl habitat along the Thames River, which increases the probability that waterfowl are impacting the impaired tributary. Geese and other waterfowl are known to congregate in open areas including recreational fields, agricultural crop fields, and golf courses. In addition to creating a nuisance, large numbers of geese can also create unsanitary conditions on the grassed areas and cause water quality problems due to bacterial contamination associated with their droppings. Large populations of geese can also lead to habitat destruction as a result of overgrazing on wetland and riparian plants.

***Agricultural Activities***

Agricultural operations are an important economic activity and landscape feature in many areas of the State. Runoff from agricultural fields may contain pollutants such as bacteria and nutrients (USEPA, 2011a). This runoff can include pollutants from farm practices such as storing manure, allowing livestock to wade in nearby waterbodies, applying fertilizer, and reducing the width of vegetated buffer along the shoreline. Agricultural land use makes up 2% of the Thames River watershed. As there are no major agricultural areas near the impaired tributary, agricultural activities are most likely a small source of bacteria to Flat Brook.

**Additional Sources**

As shown in Figure 6, four landfills were identified upstream of the impaired tributary and three were identified downstream of the impaired tributary. However, there are no landfills identified within the drainage area of Flat Brook, so this is not a likely potential source of bacteria.

There may be other sources not listed here or identified in Figure 6 that contribute to the observed water quality impairment in Flat Brook. Further monitoring and investigation will confirm the listed sources and discover additional ones. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement this TMDL.

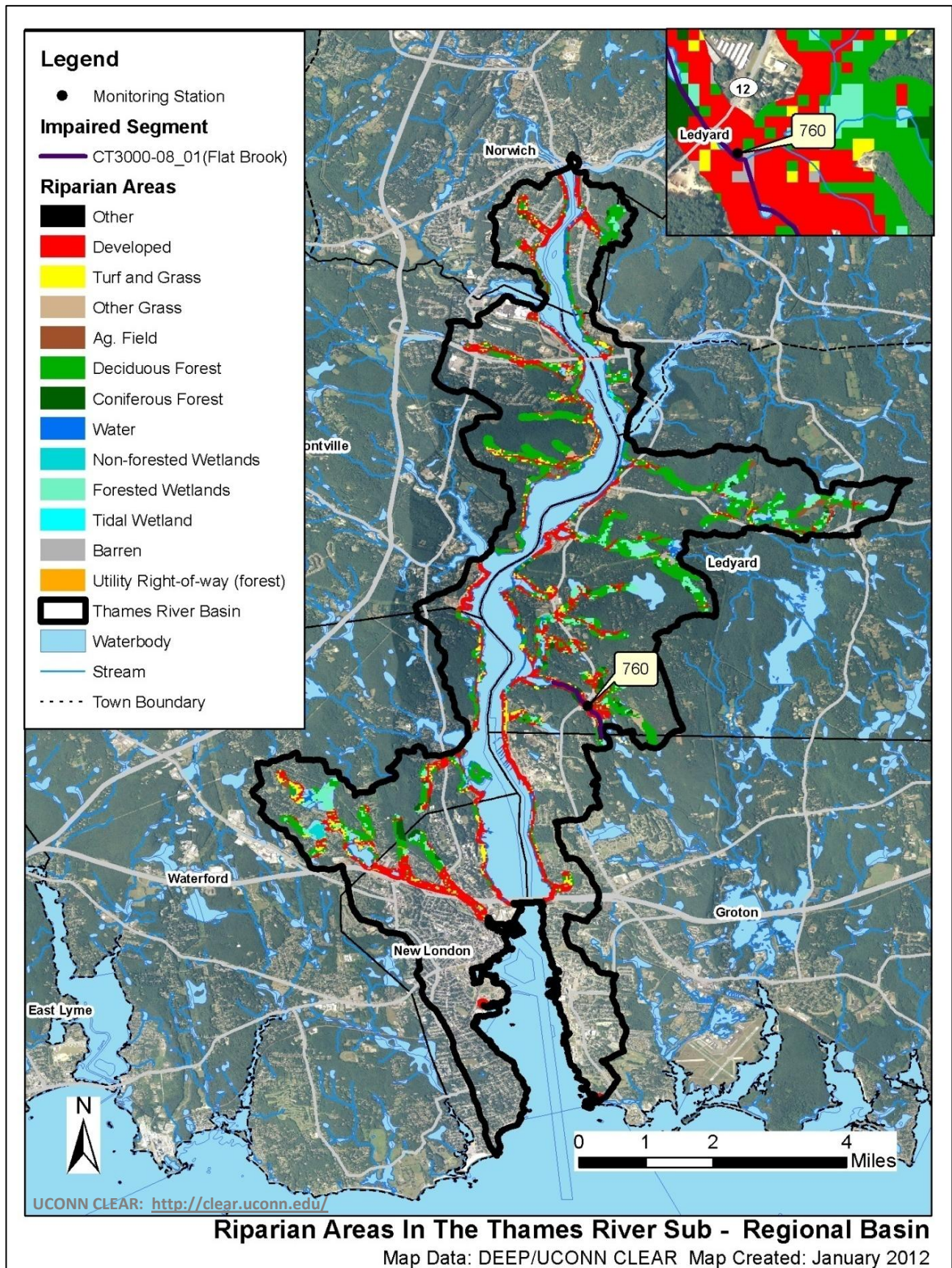
**Land Use/Landscape*****Riparian Buffer Zones***

The riparian buffer zone is the area of land located immediately adjacent to streams, lakes, or other surface waters. The boundary of the riparian zone and the adjoining uplands is gradual and not always well-defined. However, riparian zones differ from uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there. Through the interaction of their soils, hydrology, and vegetation, natural riparian areas influence water quality as contaminants are taken up into plant tissues, adsorbed onto soil particles, or modified by soil organisms. Any change to the natural riparian buffer zone can reduce the effectiveness of the natural buffer and has the potential to contribute to water quality impairment (USEPA, 2011b).

The CLEAR program at UCONN has created streamside buffer layers for the entire State of Connecticut (<http://clear.uconn.edu/>), which have been used in this TMDL. Analyzing this information can reveal potential sources and implementation opportunities at a localized level. The land use directly adjacent to a waterbody can have direct impacts on water quality from surface runoff sources.

The majority of the riparian zone for Flat Brook is characterized by developed land use (Figure 10). As previously noted, if not properly treated, runoff from developed areas may contain pollutants such as bacteria and nutrients.

Figure 10: Riparian buffer zone information for the Thames River watershed



## CURRENT MANAGEMENT ACTIVITIES

CT DEEP's Non-Point Source Pollution Program administers a Non-Point Source Grant Program with funding from EPA under Section 319 of the Clean Water Act (319 grant). A \$75,000 319 grant was awarded to the University of Connecticut's Departments of Plant Science and Cooperative Extension to create several on-site demonstration projects and season-long consultations on proper agricultural BMPs with the goal of quantifying reductions in pesticide and nutrient loading (<http://www.depdata.ct.gov/maps/nps/npsmap.htm>). A \$25,664 319 grant was awarded to the Thames River Basin Partnership to hire a coordinator to facilitate nonpoint source activities and projects to reduce NPS pollution in the Thames River basin. In addition, a \$35,000 319 grant was awarded to the Eastern Connecticut Conservation District to improve the water quality and recreational swimming area at Spaulding Pond of Mohegan Park in Norwich, CT.

As indicated previously, Ledyard and Groton are regulated under the MS4 program. The MS4 General Permit is required for any municipality with urbanized areas that initiates, creates, originates or maintains any discharge of stormwater from a storm sewer system to waters of the State. The MS4 permit requires towns to design a Stormwater Management Plan (SMP) to reduce the discharge of pollutants in stormwater to improve water quality. The plan must address the following 6 minimum measures:

1. Public Education and Outreach.
2. Public Involvement/Participation.
3. Illicit discharge detection and elimination.
4. Construction site stormwater runoff control.
5. Post-construction stormwater management in new development and redevelopment.
6. Pollution prevention/good housekeeping for municipal operations.

Each town is also required to submit an annual update outlining the steps they are taking to meet the six minimum measures. All updates that address bacterial contamination in the watershed are summarized in Tables 6 and 7.

**Table 6: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Ledyard, CT (Permit # GSM000099)**

Minimum Measure	Ledyard MS4 General Permit (2011)
Public Outreach and Education	1) No updates.
Public Involvement and Participation	1) Involved in Hazardous Waste Recycling program.
Illicit Discharge Detection and Elimination	1) Completed storm sewer outfall mapping and GIS data imported. 2) Town employees trained to note potential illicit discharges during storm drainage inspections.
Construction Site Stormwater Runoff Control	1) Conducted site inspections to ensure implementation of BMPs.
Post Construction Stormwater Management	1) Required mitigation measure when proposed development would likely cause an increase in volume or rate of stormwater runoff.
Pollution Prevention and Good Housekeeping	1) Conducted annual street sweeping and catch basin cleaning. 2) Reduced sediment load by switching to Ice-B-Gone, a treated salt for winter road deicing.

**Table 7: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Groton, CT (Permit # GSM000055)**

Minimum Measure	Groton MS4 General Permit (2011)
Public Outreach and Education	1) Included stormwater runoff information in the Department of Parks and Recreation 'Discover' magazine. 2) Aired a video on non-point pollution on local cable access channel. 3) Developed a stormwater webpage to inform citizens on improper waste disposal and illegal discharges to the MS4. 4) Distributed brochure on picking up dog waste with every issued dog license.
Public Involvement and Participation	1) Encouraged public involvement in implementing the draft SWMP, annual report, and stormwater committee meetings. 2) Sponsored a Household Hazardous Waste Collection Day.
Illicit Discharge Detection and Elimination	1) Conducted dry weather outfall screening. 2) Mapped all catch basins, drain manholes, stormwater pipes, and outfalls (greater than 12").
Construction Site Stormwater Runoff Control	1) Updated stormwater quality and stormwater management standards.
Post Construction Stormwater Management	1) Will propose zoning regulations requiring developers to use specific standards in designing and constructing stormwater controls.
Pollution Prevention and Good Housekeeping	1) Conducted annual street sweeping and catch basin cleaning. 2) Switched to salt for winter road deicing. 3) Installed five dog waste stations at various parks.

**RECOMMENDED NEXT STEPS**

The Towns of Ledyard and Groton have developed and implemented programs to protect water quality from bacterial contamination. Future mitigative activities are necessary to ensure the long-term protection of Flat Brook and have been prioritized below.

**1) Continue monitoring of permitted sources.**

Previous MS4 outfall sampling at CIP-1 at Baldwin Hill Road and CIP-2 at Flat Brook Drive in Ledyard, CT have exceeded single sample values for *E. coli* WQS multiples times in 2006, 2008, and 2009 (Table 5). Further monitoring will provide information essential to better locate, understand, and reduce pollution sources. If any current monitoring is not done with appropriate bacterial indicator based on the receiving water, then a recommended change during the next permit reissuance is to include the appropriate indicator species. If facility monitoring indicates elevated bacteria, then implementation of permit required, and voluntary measures to identify and reduce sources of bacterial contamination at the facility are an additional recommendation. Regular monitoring should be established for all permitted sources to ensure compliance with permit requirements and to determine if current requirements are adequate or if additional measures are necessary for water quality protection.

Section 6(k) of the MS4 General Permit requires a municipality to modify their Stormwater Management Plan to implement the TMDL within four months of TMDL approval by EPA if stormwater within the municipality contributes pollutant(s) in excess of the allocation established by the TMDL. For discharges to impaired waterbodies, the municipality must assess and modify the six minimum measures of its plan, if necessary, to meet TMDL standards. Particular focus should be placed on the following plan components: public education, illicit discharge detection and elimination, stormwater structures cleaning, and the repair, upgrade, or retrofit of storm sewer structures. The goal of these modifications is to establish a program that improves water quality consistent with TMDL requirements. Modifications to the Stormwater Management Plan in response to TMDL development should be submitted to the Stormwater Program of DEEP for review and approval.

Table 8 details the appropriate bacteria criteria for use as waste load allocations established by this TMDL for use as water quality targets by permittees as permits are renewed and updated, within the Thames watershed.

For any municipality subject to an MS4 permit and affected by a TMDL, the permit requires a modification of the SMP to include BMPs that address the included impairment. In the case of bacteria related impairments municipal BMPs could include: implementation or improvement to existing nuisance wildlife programs, septic system monitoring programs, any additional measures that can be added to the required illicit discharge detection and elimination (IDDE) programs, and increased street sweeping above basic permit requirements. Any non-MS4 municipalities can implement these same types of initiatives in effort to reduce bacteria source loading to impaired waterways.

Any facilities that discharge non-MS4 regulated stormwater should update their Pollution Prevention Plan to reflect BMPs that can reduce bacteria loading to the receiving waterway. These BMPs could include nuisance wildlife control programs and any installations that increase surface infiltration to reduce overall stormwater volumes. Facilities that are regulated under the Commercial Activities Stormwater Permit should report any updates to their SMP in their summary documentation submitted to DEEP.

**Table 8. Bacteria (*e.coli*) TMDLs, WLAs, and LAs for Recreational Use.**

Class	Bacteria Source	Instantaneous <i>E. coli</i> (#/100mL)						Geometric Mean <i>E. coli</i> (#/100mL)	
		WLA <sup>6</sup>			LA <sup>6</sup>			WLA <sup>6</sup>	LA <sup>6</sup>
	Recreational Use	1	2	3	1	2	3	All	All
A	Non-Stormwater NPDES	0	0	0				0	
	CSOs	0	0	0				0	
	SSOs	0	0	0				0	
	Illicit sewer connection	0	0	0				0	
	Leaking sewer lines	0	0	0				0	
	Stormwater (MS4s)	235 <sup>7</sup>	410 <sup>7</sup>	576 <sup>7</sup>				126 <sup>7</sup>	
	Stormwater (non-MS4)				235 <sup>7</sup>	410 <sup>7</sup>	576 <sup>7</sup>		126 <sup>7</sup>
	Wildlife direct discharge				235 <sup>7</sup>	410 <sup>7</sup>	576 <sup>7</sup>		126 <sup>7</sup>
	Human or domestic animal direct discharge <sup>5</sup>				235	410	576		126

- (1) **Designated Swimming.** Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protections and the Department of Public Health. May 1989. Revised April 2003 and updated December 2008.
- (2) **Non-Designated Swimming.** Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.
- (3) **All Other Recreational Uses.**
- (4) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23. (Class B surface waters located north of Interstate Highway I-95 and downstream of a sewage treatment plant providing seasonal disinfection May 1 through October 1, as authorized by the Commissioner.)
- (5) Human direct discharge = swimmers
- (6) Unless otherwise required by statute or regulation, compliance with this TMDL will be based on ambient concentrations and not end-of-pipe bacteria concentrations
- (7) Replace numeric value with "natural levels" if only source is naturally occurring wildlife. Natural is defined as the biological, chemical and physical conditions and communities that occur within the environment which are unaffected or minimally affected by human influences (CT DEEP 2011a). Sections 2.2.2 and 6.2.7 of this Core Document deal with BMPs and delineating type of wildlife inputs.

## 2) Identify areas along Flat Brook to implement Best Management Practices (BMPs) to control stormwater runoff.

As noted previously, 44% of the Thames River watershed is considered urban, and the Towns of Ledyard and Groton are MS4 communities regulated by the MS4 program. Station 760, located within the urban portion of Flat Brook, exceeded the geometric mean during wet-weather. As such, stormwater runoff is most likely contributing bacteria to the waterbodies. To identify other areas that are contributing bacteria to the impaired tributary, the towns should continue to conduct wet-weather sampling at stormwater outfalls that discharge directly to Flat Brook. Outfalls that have previously shown high bacteria concentrations should be prioritized for BMP installation (Table 5). To treat stormwater runoff, the towns should identify areas along the impaired segment to install BMPs that encourage stormwater to infiltrate into the ground before entering the waterbodies. These BMPs would disconnect impervious areas and reduce pollutant loads to the river. More detailed information and BMP recommendations can be found in the core TMDL document.

**3) Evaluate municipal education and outreach programs regarding animal waste.**

As most of the riparian zone of Flat Brook is developed and flows through forested residential areas, any education and outreach program should highlight the importance of managing waste from horses, dogs, and other pets and not feeding waterfowl and wildlife. The town and residents can take measures to minimize waterfowl-related impacts such as allowing tall, coarse vegetation to grow in the riparian areas of Flat Brook that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. In addition, any educational program should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in Flat Brook and can harm human health and the environment. Animal wastes should be disposed of away from any waterbody or storm drain system. BMPs effective at reducing the impact of animal waste on water quality include installing signage, providing pet waste receptacles in high-use areas, enacting ordinances requiring the clean-up of pet waste, and targeting educational and outreach programs in problem areas.

**4) Develop a system to monitor septic systems.**

Though the lower portion of the Thames River watershed relies on the municipal sanitary sewer system, residents in the drainage area of Flat Brook rely on septic systems. If not already in place, Ledyard and Groton should establish a program to ensure that existing septic systems are properly operated and maintained, and create an inventory of existing septic systems through mandatory inspections. Inspections help encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of sub-standard systems within a reasonable timeframe can be adopted. Ledyard and Groton can also develop a program to assist citizens with the replacement and repair of older and failing systems.

## BACTERIA DATA AND PERCENT REDUCTIONS TO MEET THE TMDL

**Table 9: Flat Brook Bacteria Data****Waterbody ID:** CT3000-08\_01**Characteristics:** Freshwater, Class A, Potential Drinking Water Supplies, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, Navigation, and Industrial and Agricultural Water Supply**Impairment:** Recreation (*E. coli* bacteria)**Water Quality Criteria for *E. coli*:**

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

**Percent Reduction to meet TMDL:**Geometric Mean: **81%**Single Sample: **97%****Data:** 2006-2009 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle**Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated**

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/21/2006	300	dry	228
760	Baldwin Hill Road	6/28/2006	2600	dry	
760	Baldwin Hill Road	7/3/2006	159 <sup>†</sup>	dry	
760	Baldwin Hill Road	7/11/2006	1100	dry	
760	Baldwin Hill Road	7/18/2006	220	dry	
760	Baldwin Hill Road	7/27/2006	61	dry	
760	Baldwin Hill Road	8/2/2006	220	dry	
760	Baldwin Hill Road	8/9/2006	120 <sup>†</sup>	dry	
760	Baldwin Hill Road	8/16/2006	220	wet	
760	Baldwin Hill Road	8/23/2006	85	dry	
760	Baldwin Hill Road	9/11/2006	96	dry	

Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/6/2007	350	wet	679* (81%)
760	Baldwin Hill Road	6/13/2007	420	dry	
760	Baldwin Hill Road	6/20/2007	380	dry	
760	Baldwin Hill Road	7/11/2007	450	dry	
760	Baldwin Hill Road	7/19/2007	1300	wet	
760	Baldwin Hill Road	7/26/2007	465 <sup>†</sup>	dry	
760	Baldwin Hill Road	8/9/2007	1000	wet	
760	Baldwin Hill Road	8/23/2007	390	wet	
760	Baldwin Hill Road	9/4/2007	350 <sup>†</sup>	dry	
760	Baldwin Hill Road	9/12/2007	10000	wet	
760	Baldwin Hill Road	6/4/2008	5300 <sup>†</sup>	wet**	333
760	Baldwin Hill Road	6/11/2008	340	dry**	
760	Baldwin Hill Road	6/19/2008	400 <sup>†</sup>	dry**	
760	Baldwin Hill Road	6/25/2008	380	wet**	
760	Baldwin Hill Road	7/2/2008	115 <sup>†</sup>	dry**	
760	Baldwin Hill Road	7/9/2008	310	dry**	
760	Baldwin Hill Road	7/16/2008	130	dry**	
760	Baldwin Hill Road	7/23/2008	110	wet**	
760	Baldwin Hill Road	7/30/2008	120	dry**	
760	Baldwin Hill Road	8/6/2008	14000* (97%)	wet**	
760	Baldwin Hill Road	8/13/2008	110	dry**	
760	Baldwin Hill Road	8/21/2008	73	dry**	

Single sample *E. coli* (colonies/100 mL) data from Station 760 on Flat Brook with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
760	Baldwin Hill Road	6/3/2009	110	dry**	151
760	Baldwin Hill Road	6/11/2009	140 <sup>†</sup>	wet**	
760	Baldwin Hill Road	6/25/2009	150 <sup>†</sup>	dry**	
760	Baldwin Hill Road	7/9/2009	180	wet	
760	Baldwin Hill Road	7/16/2009	98	dry	
760	Baldwin Hill Road	7/23/2009	230	wet	
760	Baldwin Hill Road	7/29/2009	120	dry	
760	Baldwin Hill Road	8/13/2009	280 <sup>†</sup>	dry	
760	Baldwin Hill Road	8/20/2009	129 <sup>†</sup>	dry	

Shaded cells indicate an exceedance of water quality criteria

<sup>†</sup> Average of two duplicate samples

\*\* Weather conditions for selected data taken from Hartford because local station had missing data

\*Indicates single sample and geometric mean values used to calculate the percent reduction

Wet and dry weather geometric mean values for Station 760 on Flat Brook

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
760	Baldwin Hill Road	2006-2009	13	29	302	683	209

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gages at Norwich Public Utility Plant in Norwich, CT and Hartford Bradley International Airport

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